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ENVIRONMENTAL STEWARDSHIP AND SUSTAINABILITY

Ultra Low Freezer
Performance and Energy Use

Sanyo VIP Series
Model MDF U76VC

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Product Website: http://us.sanyo.com/Biomedical-Preservation-Ultra-Low-Temperature-Freezers-Upright/MDF-U76VC-26-cu-ft-VIP-Series-86-deg-C-Ultra-Low-Temperature-Freezer

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Gratitude

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Introduction

The energy intensity of laboratories has come into focus over recent years, and Labs21 has provided a website to publish this data. As well, building designers are looking for new ways to reduce building plug load and cooling from reject heat. The energy consumption of water cooled freezers is lower than air cooled units, and reject heat is shed into process cooling loops.

During October, 2011 staff and students from the office of Environmental Stewardship and Sustainability tested three ultra low freezers (ULF, Tables 1 and 2). The manufacturers kindly shipped, helped install the freezers and advised this project. Without their enthusiastic participation it could not have occurred and we are very grateful. The results from the Sanyo freezer testing are presented here.

Distributor	**Sanyo**
Manufacturer	**Sanyo**
Model	MDF U76VC
Face Width (")	40
Door Swing Min. (")	3.5
Cubic Feet	25.7
2" Boxes	575
Boxes/Linear Foot	159

Table 1. Ultra Low Freezer dimensions and capacities.

Distributor	**Sanyo**
Manufacturer	**Sanyo**
Outer Door Hinge	3 ea barrel, 10 cm
Door Swing	120°
Outer Door	3" VIP
Latch	Cam, Manual
Gaskets	Door & Frame;
Inner Doors	Insulated with Gaskets
Vacuum Relief	Manual Knob Unheated, sealed
Noise	Quiet

Table 2. Freezer Construction and Doors. The Sanyo has vacuum sealed walls that are thin and allow a lighter design overall.

Testing methods

Energy

We used Elite Pro energy meters on loan to UC Davis from the Pacific Gas and Electric Tool Lending Library, set up with 15 Amp current transducers (CT's). Split cord pigtails provided single conductors for CT placement, or CT's were placed over single conductors inside the mechanical cabinet. All three freezer amperages were measured simultaneously to obtain Volt-Amp values. Power factor was measured individually on each freezer by attaching voltage clips in a bare wire outlet box before energizing and then insulated, thus avoiding live connection hazards. We multiplied Volt-Amps by the power factors to calculate Watts during subsequent tests. Freezers were allowed to stabilize at each temperature for 6 –10 hours, then energy measurements were logged either at 1 minute or 5 minute intervals and averaged over at least 8 hours. Freezers were empty during all tests.

Temperature

On the recommendation of cryo-temperature experts in the UC Davis Physics Department, we selected type J thermocouple (TC) wire for temperature sensing. We cut and welded 13 TC's at either 3 or 5 meters, and attached them to type J plugs. They were inter-calibrated for precision in a methanol bath with dry ice chunks and stirring. Three TC's were measured during both calibration sessions and averaged. Offsets from these averages were calculated for each TC and were applied to temperature readings, (Appendix B).

Up to eight TC's were logged simultaneously using an Omega TC-08 panel. Two TC's were placed in each ULF, one next to the installed temperature probe, and one in the geometric center of the cabinet, about 4 cm above the shelf. Intake air temperature was logged on the grill. Occasional room temperature measurements were made with an infrared thermometer, and room temperature was 23.0 +- 0.3 C.

Results

Temperature Characteristics

The purpose of this test was not detailed assessment of spatial and temporal uniformity. Some data was collected from the two TC's in the middle of the freezer and next to the sensor, (Table 3). As seen in Figure 2, the middle of the freezers was generally 2° colder than at the sensors, which were near the bottom of the freezers.

	Sanyo
Mean of Both TCs	-81.7
Max-Min	5.55
Measured - Set Point	-1.65
Sensor - Middle	1.03

Table 3. Temperature values over time and uniformity in the cabinet, (set point -80 degrees).

Energy Consumption

The Sanyo ULF consumed about 17 kWh/d at -80 °C, (Table 4). The energy intensity per box and cubic foot were also calculated .

	Sanyo
Energy Use kWh/d	17.4
Power Factor	0.97
Energy Intensity (W/CF)	28.2
Energy Intensity (W/Box)	1.26
Electricity Cost/y (8.5 c/kWh)	$ 540
Electricity Cost/Box/y	$ 0.94

Table 4. Energy consumption and intensity at the set point -80 °C.

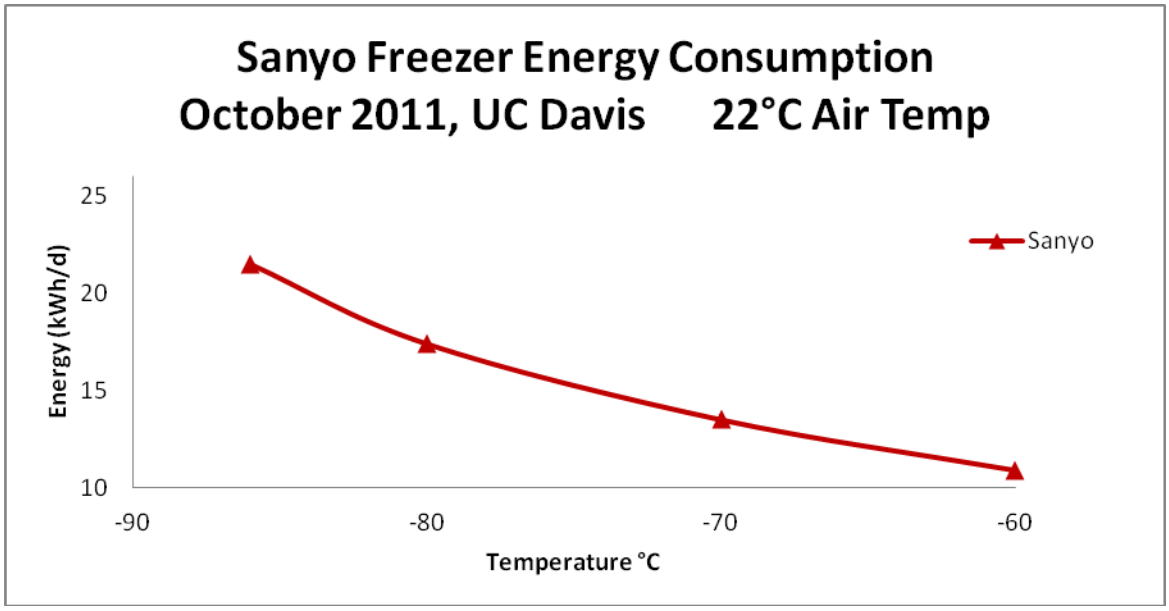


Figure 1. Energy consumption of Sanyo ultra low freezer at four set points.

Appendices.

A) Complete temperature measurements and deviations.

Mean Temperature	Measured at Sensor
-80	-82.7

Mean Temperature	Measured at Middle
-80	-80.6

Sensor °C - Middle °C	
-80	1.03

Range Max-Min	
-80	5.55

Sensor °C -Set Point	
-80	-1.65

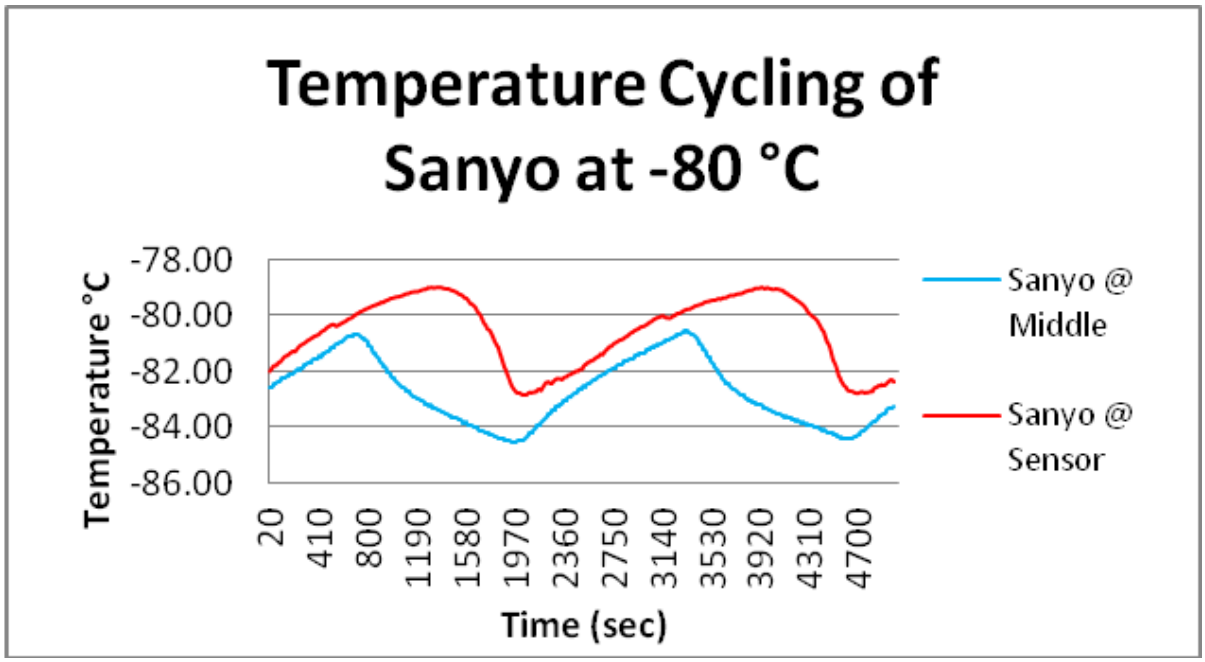
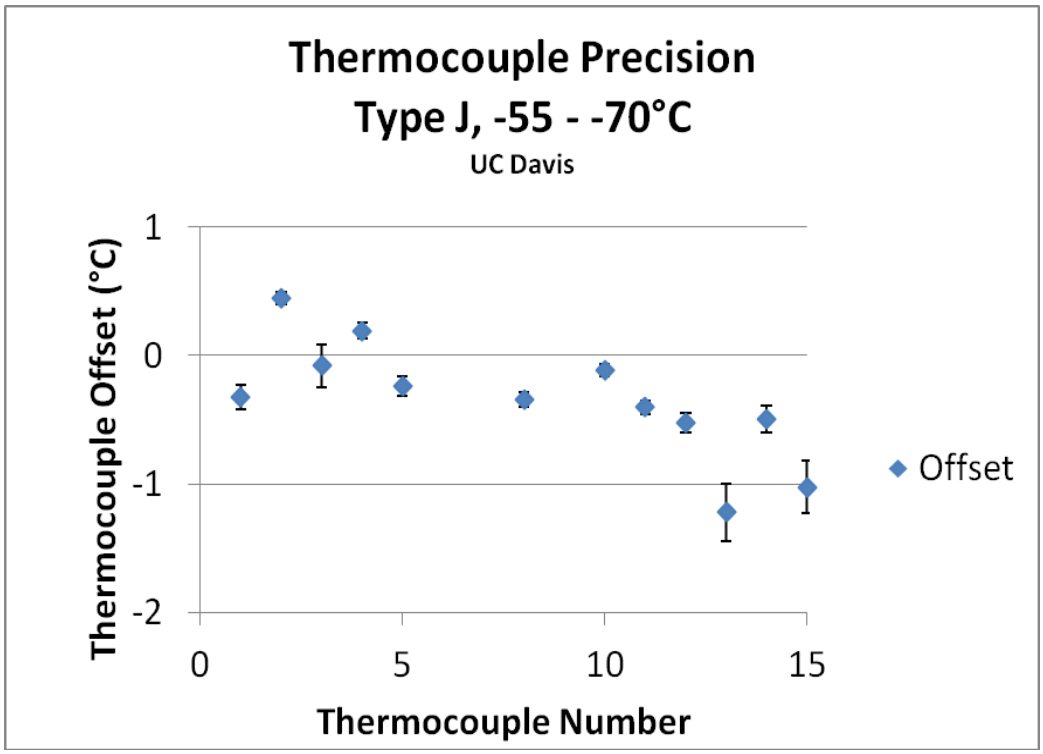
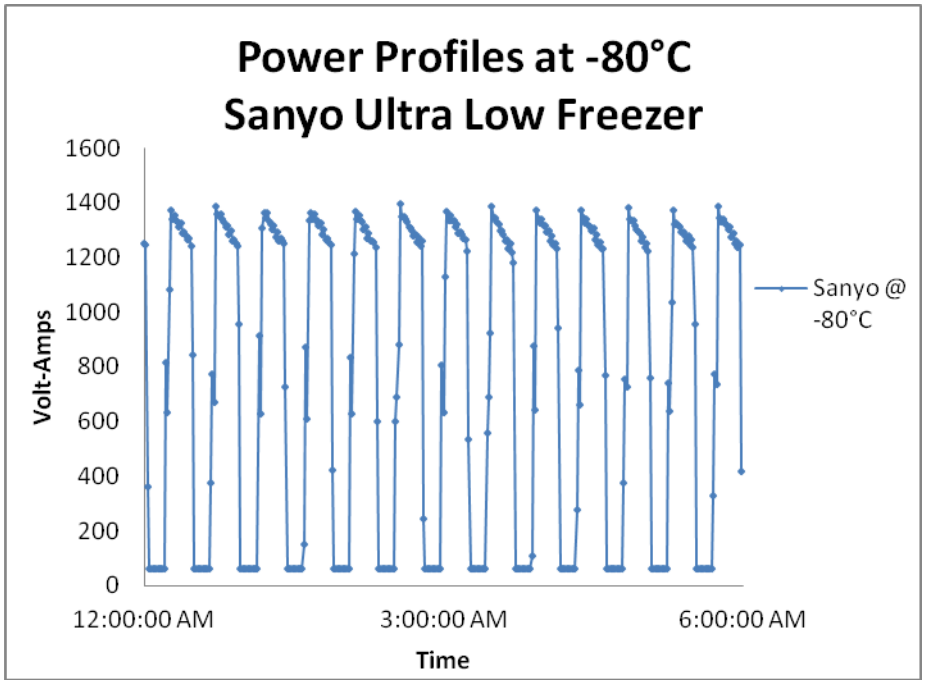


Figure 2. Temperature cycling of Sanyo at -80°C shows that the middle of the freezer was 1 to 3° colder than temperatures at the sensor

B) Thermocouple Precision measured in methanol and dry ice bath. The thermocouples were generally within 0.5 °C, though two were a degree or more from a mean of four TC's. Offsets were applied to each thermocouple's data.



C) Sanyo Power profiles at -80 degrees Celsius



D) Example Sanyo power data at -80 degrees Celsius

Date	End Time	Avg. Volt	Avg. Amp	Avg. PF
9/28/2011	0:00:00	205	6.11	0.31
9/28/2011	0:01:00	205	6.08	0.32
9/28/2011	0:02:00	205.1	1.76	0.32
9/28/2011	0:03:00	205.3	0.31	0.32
9/28/2011	0:04:00	205.2	0.31	0.32
9/28/2011	0:05:00	205.1	0.31	0.32
9/28/2011	0:06:00	205	0.31	0.32
9/28/2011	0:07:00	204.9	0.31	0.32
9/28/2011	0:08:00	205	0.31	0.32
9/28/2011	0:09:00	204.6	0.31	0.32
9/28/2011	0:10:00	203.9	0.31	0.32
9/28/2011	0:11:00	203.8	0.31	0.32
9/28/2011	0:12:00	203.8	0.31	0.32
9/28/2011	0:13:00	203.9	4	0.26
9/28/2011	0:14:00	204.1	3.11	0.11
9/28/2011	0:15:00	204	5.3	0.29
9/28/2011	0:16:00	204	6.73	0.34
9/28/2011	0:17:00	204	6.57	0.33
9/28/2011	0:18:00	204.1	6.63	0.34
9/28/2011	0:19:00	204.1	6.55	0.33
9/28/2011	0:20:00	204	6.51	0.33
9/28/2011	0:21:00	204.7	6.41	0.34
9/28/2011	0:22:00	205	6.46	0.33
9/28/2011	0:23:00	205	6.29	0.33
9/28/2011	0:24:00	205	6.31	0.33
9/28/2011	0:25:00	205	6.23	0.33
9/28/2011	0:26:00	204.9	6.18	0.32
9/28/2011	0:27:00	204.8	6.19	0.32
9/28/2011	0:28:00	204.7	6.06	0.31
9/28/2011	0:29:00	204.8	4.11	0.32
9/28/2011	0:30:00	205	0.31	0.32
9/28/2011	0:31:00	204.6	0.31	0.32
9/28/2011	0:32:00	204.1	0.31	0.31
9/28/2011	0:33:00	203.8	0.31	0.31
9/28/2011	0:34:00	204	0.31	0.32
9/28/2011	0:35:00	204.2	0.31	0.32
9/28/2011	0:36:00	204.3	0.31	0.32
9/28/2011	0:37:00	204.3	0.31	0.32
9/28/2011	0:38:00	204.3	0.31	0.32
9/28/2011	0:39:00	204.3	0.31	0.32